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SOVIET LONG-DISTANCE POWER TRANSMISSION LINES

M. Yakovlev

The Moscow Power System unites a great many electric power stations. In a few years, the Kuybyshev and Stalingrad GES (hydroelectric power stations) will be incorporated in it. The Volga giants will deliver up to 10-billion kwhr of electric energy each year to the Moscow Power System by means of long-distance transmission lines. These lines will be the longest in the world, for it is over 900 km from Kuybyshev to Moscow and over 1,000 km from Stalingrad to Moscow. The maximum length of existing transmission lines is 300-350 km with a transmitted power of 300,000 kw.

As a result of thorough studies, Soviet scientists determined that the most favorable voltage for ac power transmission from Kuybyshev and Stalingrad to Moscow was 400 kv instead of the 220 kv now used in high-power networks. Higher voltages would necessitate larger towers, thicker insulation, and higher construction costs. Moreover, use of 400 kv helps solve the main problem in long-distance transmission, namely stability.

The generators of all stations in a power system must operate at constant speed, a speed which is determined by the electromagnetic forces developed in each generator. But these forces decrease with an increase in the length of the line, and abrupt changes of the load disturb parallel operation. Some of the turbines used to drive the generators continuously pick up speed and all the power developed is expended on this acceleration /runaway condition/.

Soviet scientists discovered the causes of these effects and developed methods of controlling them in existing transmission lines. However, they have not yet solved the problem of controlling electromagnetic forces on very long lines so that the generators of the Kuybyshev and Stalingrad GES will always rotate in conformity with the generators of the other Volga stations of the Moscow power system at Ivanovo, Uglich, and Shcherbakovo (over 1,000 km distant).

Planning very long lines to transmit enormously high power requires exact mathematical analysis and thorough experimental verification of all processes on models.

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The first part of a working model of the Kuybyshev GES has been built under the supervision of V. A. Venikov, Candidate in Technical Sciences, in the Water Power Laboratory of the Moscow Power Engineering Institute imeni Molotov (director, Professor T. L. Zolotarev, Doctor of Technical Sciences. The model consists of two turbines, two generators, and a very long transmission line. A. V. Ivanov-Smolenskiy, Candidate in Technical Sciences; L. S. Lifshits, engineer; and O. I. Zeyegofer, engineer; also worked on this model. However, there is no model of the Volga and the dams which form the reservoirs feeding the turbines, nor are there any high towers and overhead lines. Two heavy-duty pumps send water into a tank to provide a head. The water, flowing through a pipe into the laboratory, drives a small turbine connected with the generator.

Each transmission line wire, roughly 1,000 km long, is represented in the model by 20 copper wire coils and capacitors. Each coil with its capacitor corresponds in electrical properties to 50 km of the planned trunk line. To this transmission line, an ac voltage of 400 v is applied -- one thousandth of the planned transmission line voltage.

At times, there may be a considerable increase in the capacitance of transmission lines; the longer the line, the greater the capacitance. Enormous stores of energy will accumulate and the voltage will rise. If no provision is made for such high voltages, the insulation, not merely of the lines, but also of the transformers, generators, and other equipment of the system may break down. The institute is studying these effects to find the best method of coping with them.

When the second part of the model is finished, it will be connected into the Moscow Power System so that all the operating conditions of the Kuybyshev GES can be thoroughly examined. The model will make possible full investigation both of the purely electrical phenomena and of the mechanical and hydraulic processes associated with hydraulic turbines and their regulators.

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